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Shimoda et al.

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(54) **IMAGE SENSOR UNIT, IMAGE READING APPARATUS, AND PAPER SHEET DISTINGUISHING APPARATUS**

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G07D 7/12 (2016.01)
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CPC ***G07D 7/121*** (2013.01); ***G01N 21/86*** (2013.01); ***G01N 21/8806*** (2013.01); ***G01N 21/8914*** (2013.01); ***G07D 7/2025*** (2013.01);
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None
See application file for complete search history.

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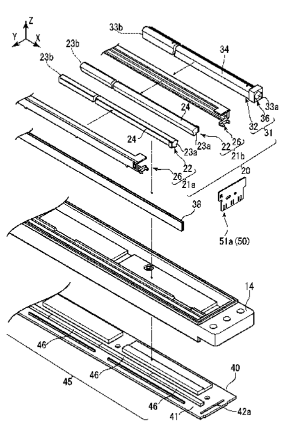
(57) **ABSTRACT**

An image sensor unit includes: a plurality of light sources each including an LED chip; a plurality of light guides that are arranged in parallel to face incident surfaces on one side in a longitudinal direction for each of the plurality of light sources and that guide light from the plurality of light sources to a bill; an image sensor that converts light from the bill to an electric signal; a sensor substrate for mounting the image sensor; and a circuit board that is provided with the plurality of light sources on a same mounting surface and that is arranged on the sensor substrate on one side in the longitudinal direction of the plurality of light guides, wherein the sensor substrate includes a connection hole on one side in the longitudinal direction of the sensor substrate, and the circuit board is connected to the sensor substrate by connecting a connecting portion including a plurality of external connection pads to the connection hole.

13 Claims, 11 Drawing Sheets



(51) **Int. Cl.**

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G01N 21/89	(2006.01)
G01J 3/02	(2006.01)
G01J 3/10	(2006.01)

(52) **U.S. Cl.**
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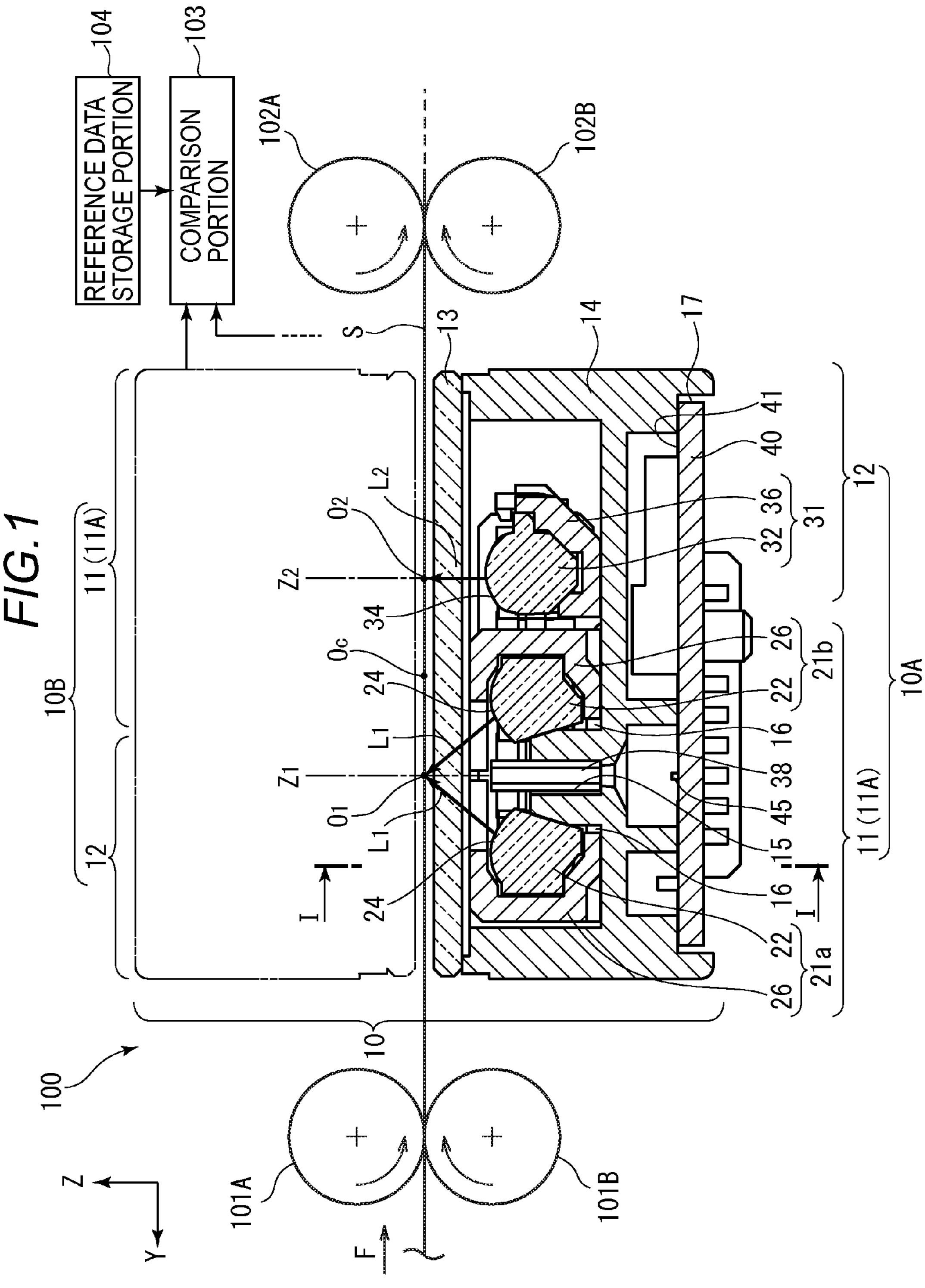
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15
16
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21a
21b
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24
26
31
32
34
36
38
40
41
45
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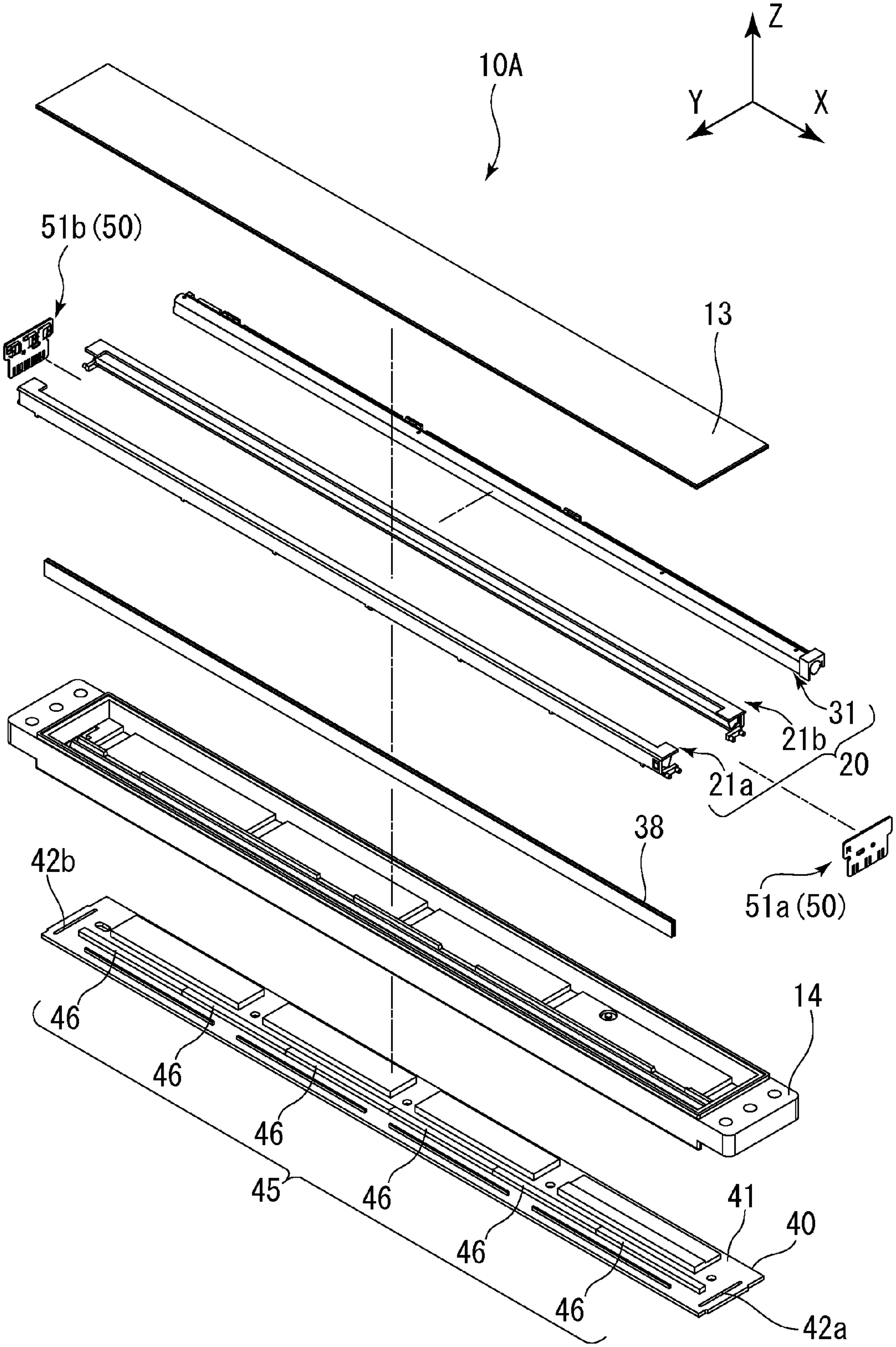
L1
L2
O1
O2
Oc
I
F
Z
Y

FIG.1

FIG.2



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21b
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45
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41
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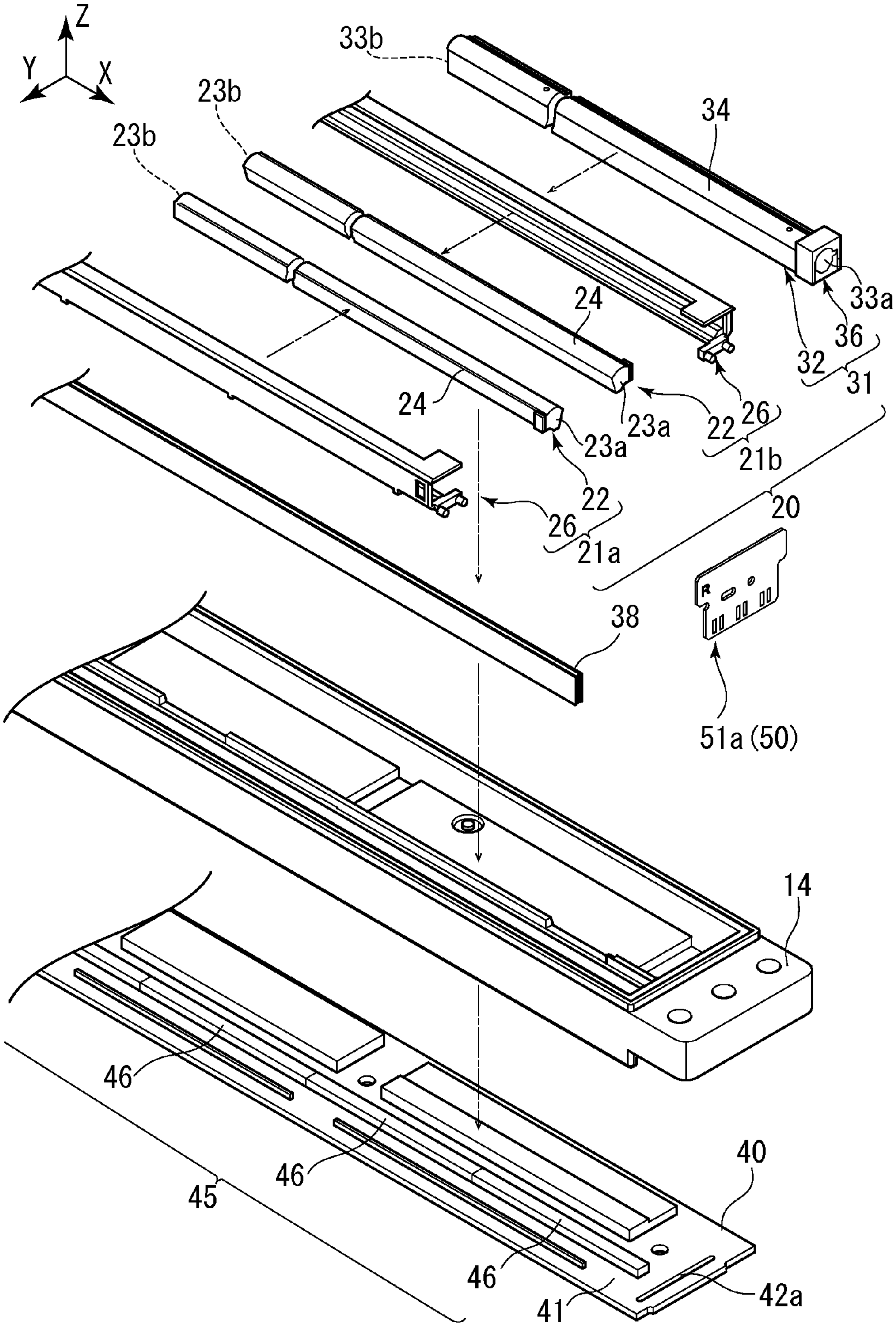
46
42a

FIG.3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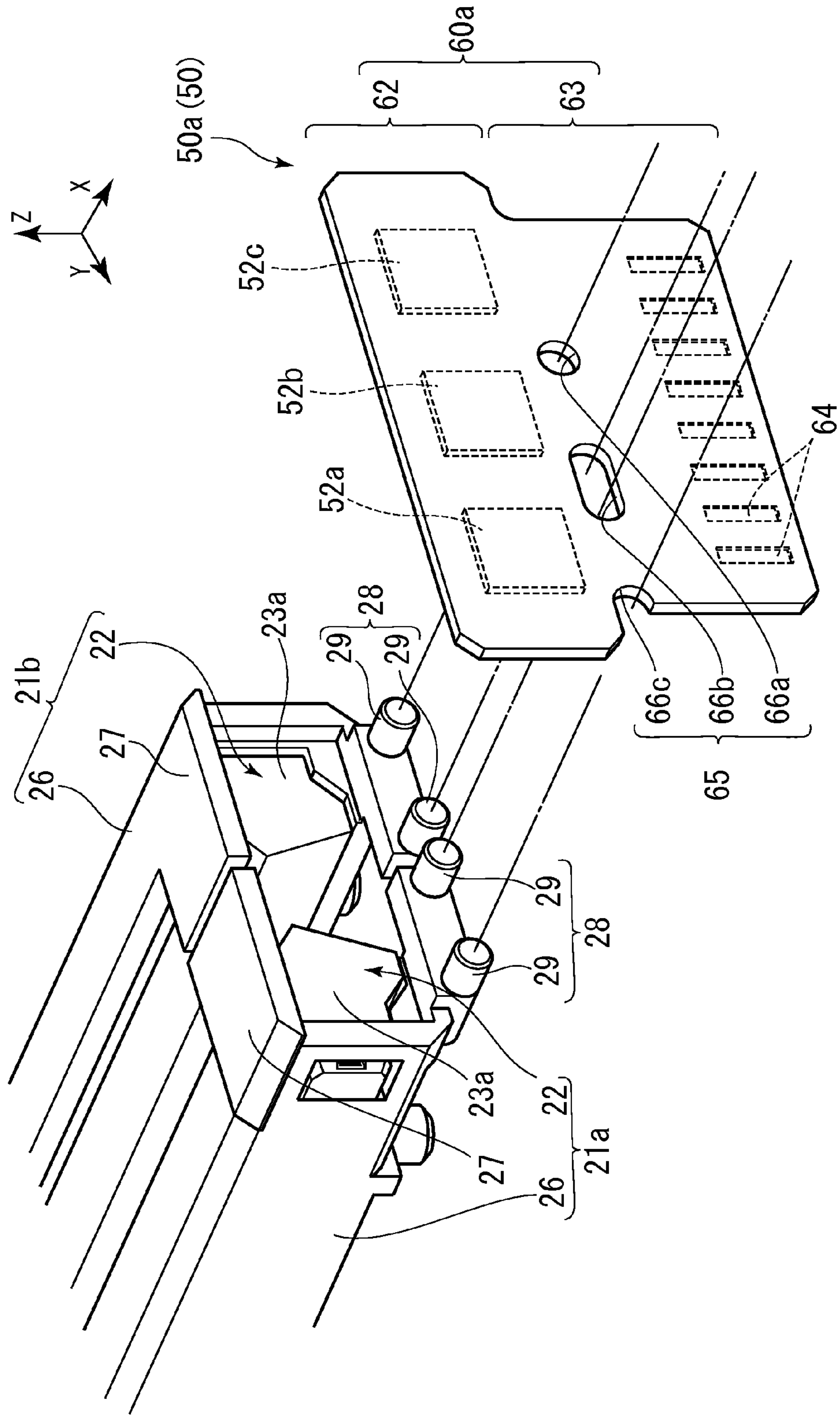
42a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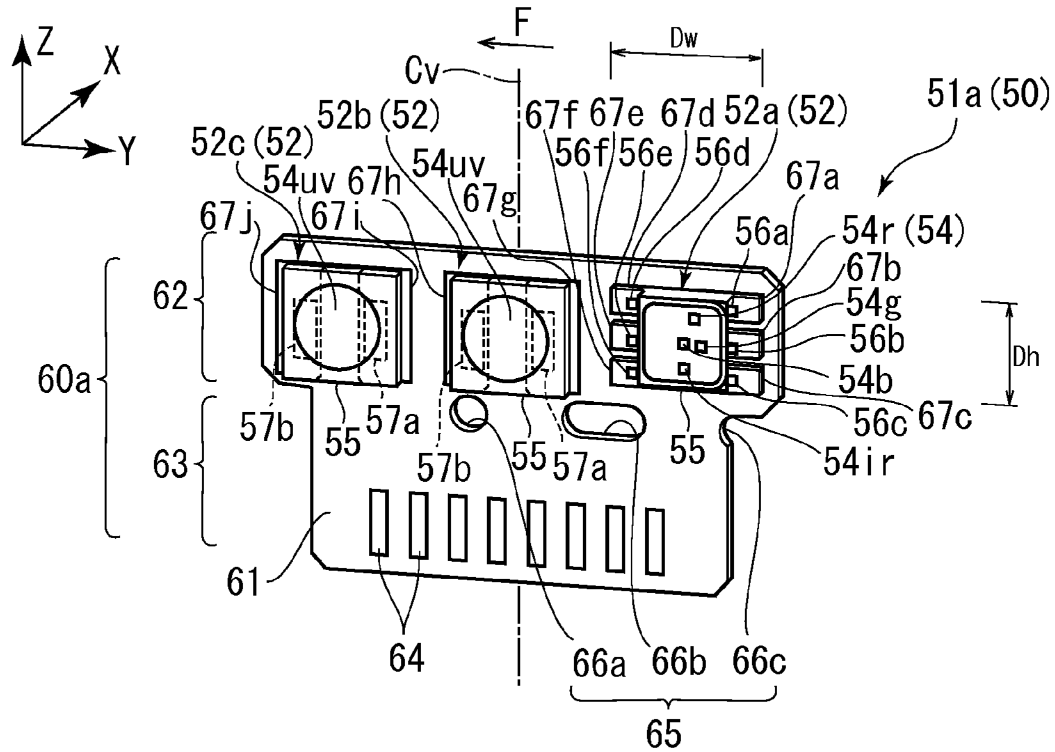
26

FIG. 4

FIG.5A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62
60a
63
57b
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66b
66c
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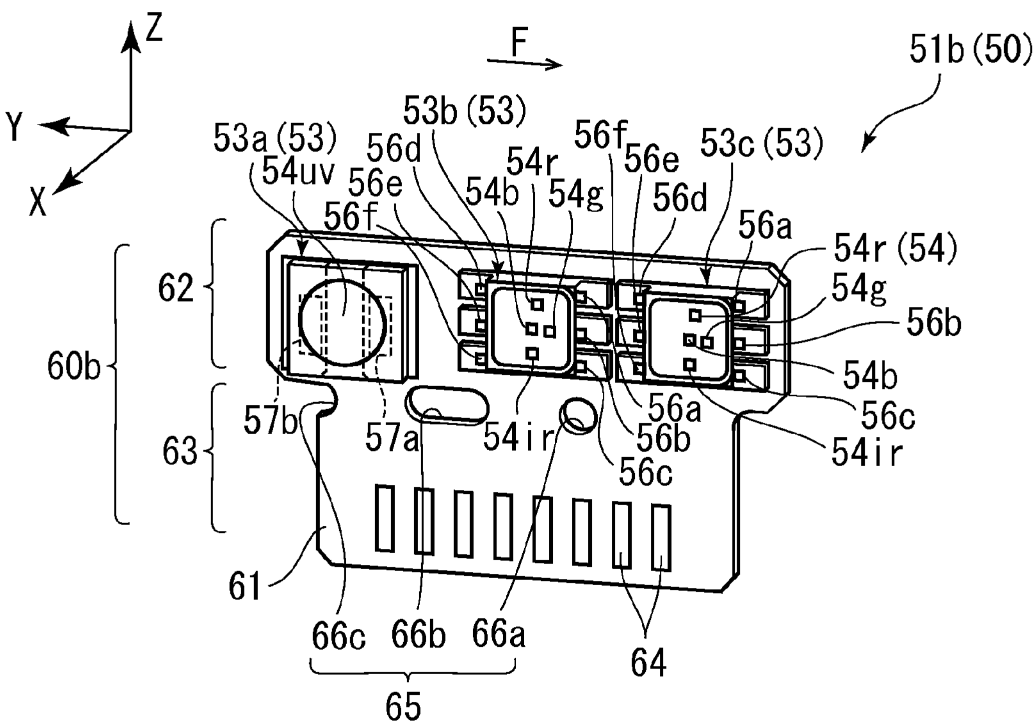
FIG.5B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66a
64
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FIG.6

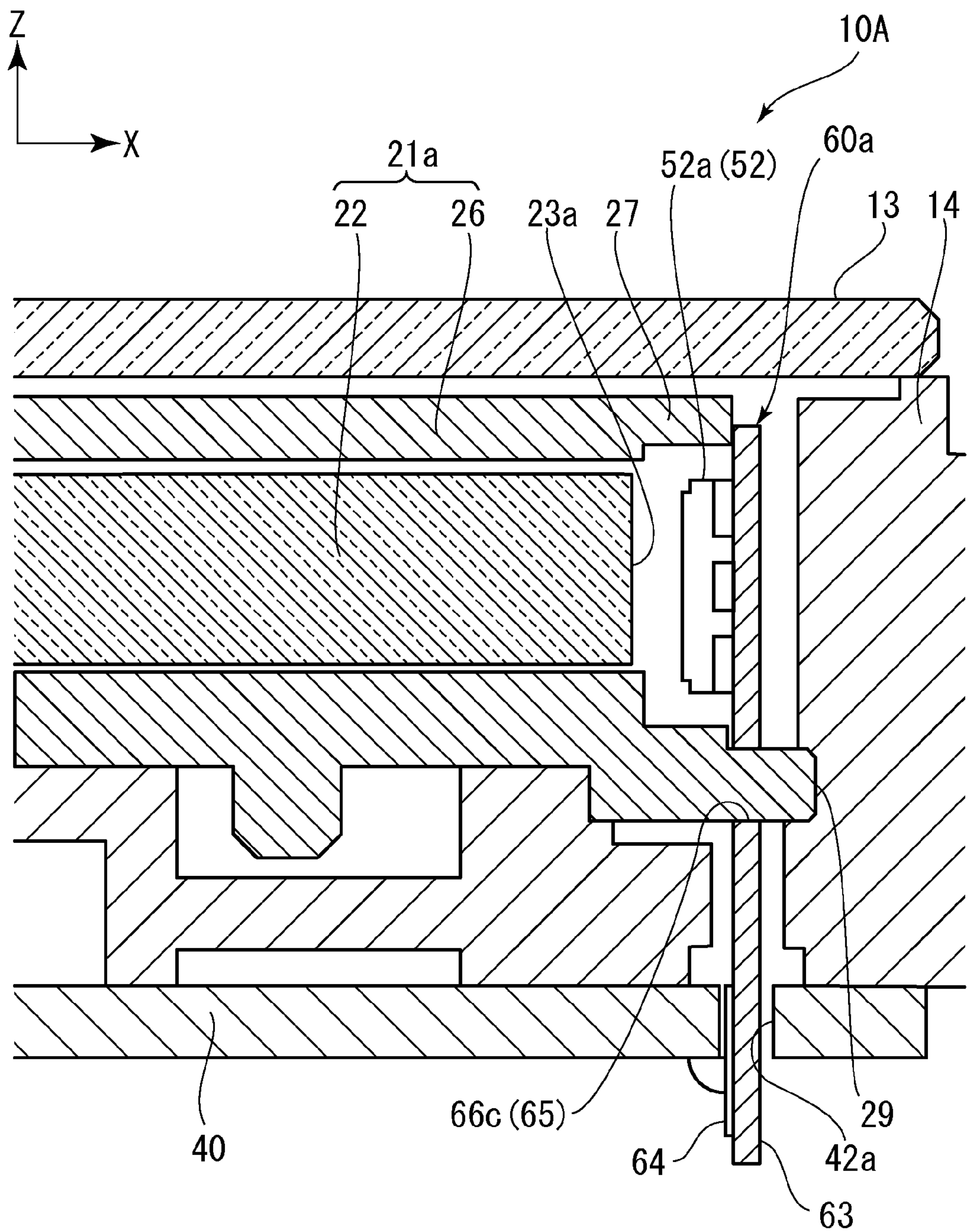
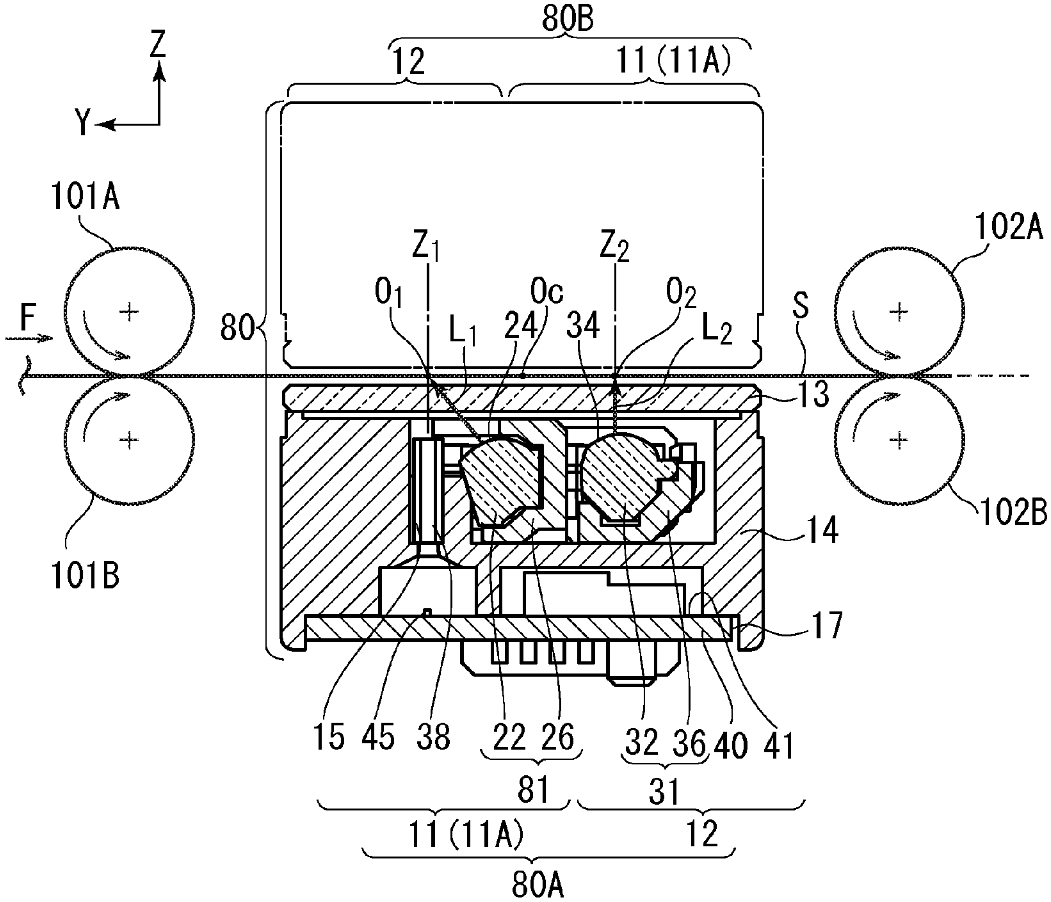


FIG.7A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O2
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L2
S
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14
17
101B
102B
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81
31
11 (11A)
12
80A

FIG.7B

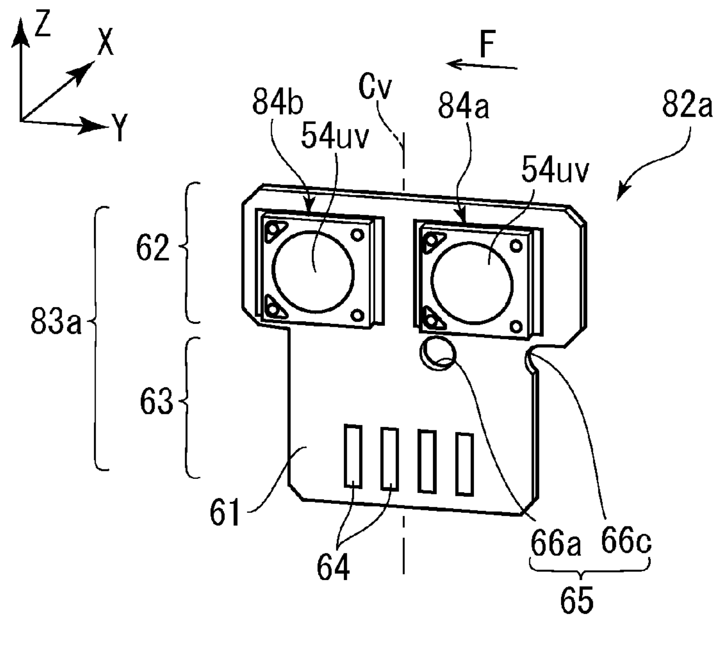
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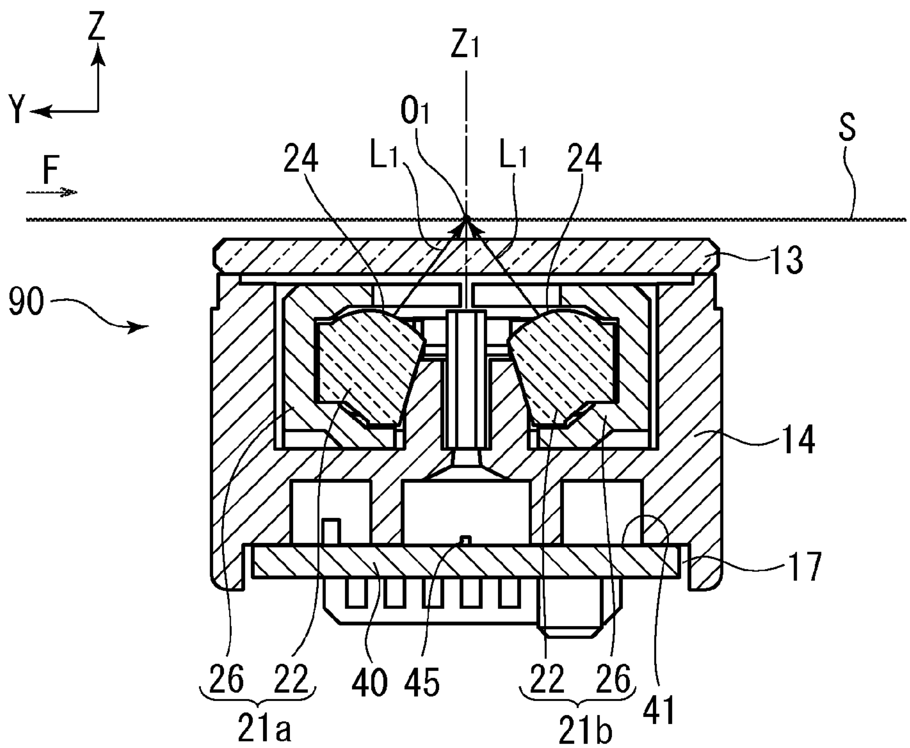
FIG.8A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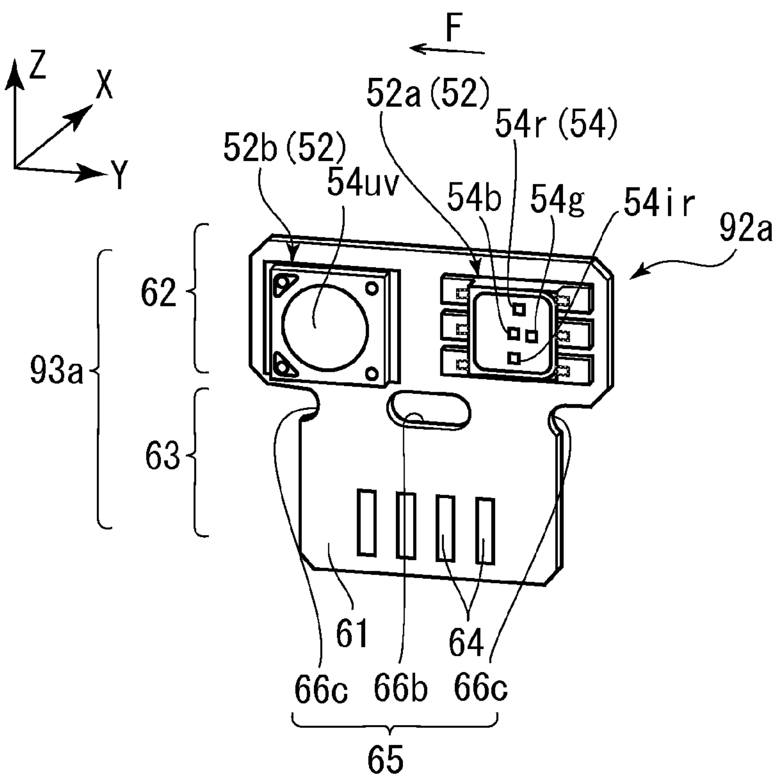
21b

FIG.8B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66c
66b
66c
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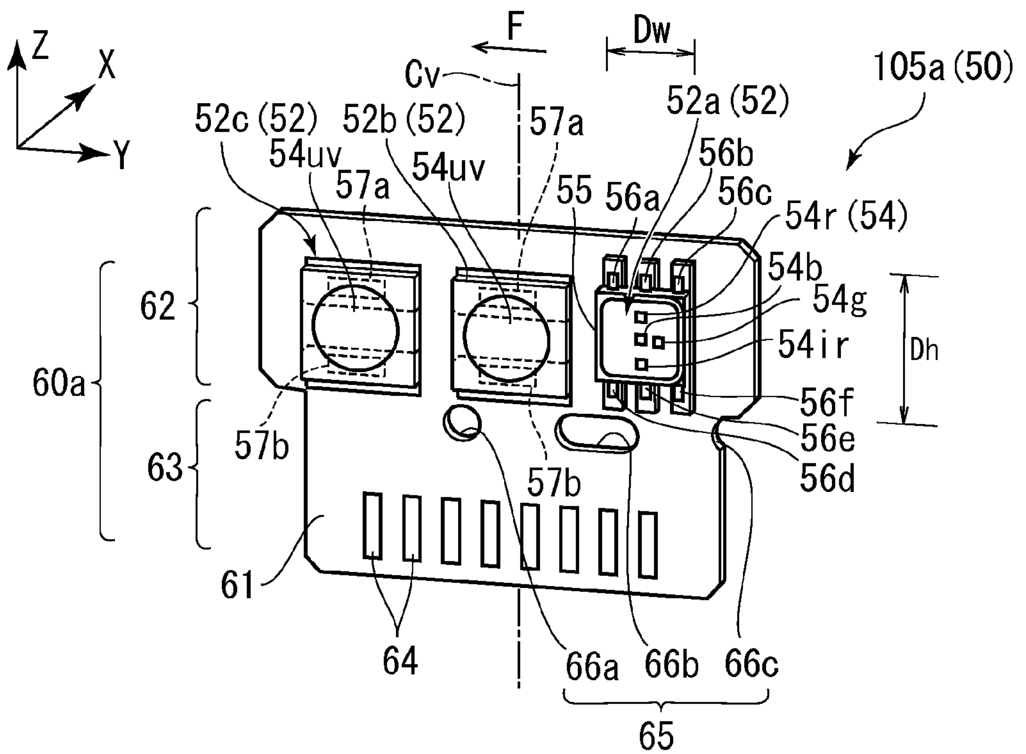
FIG.9A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56c
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54b
54g
54ir
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66b
66c
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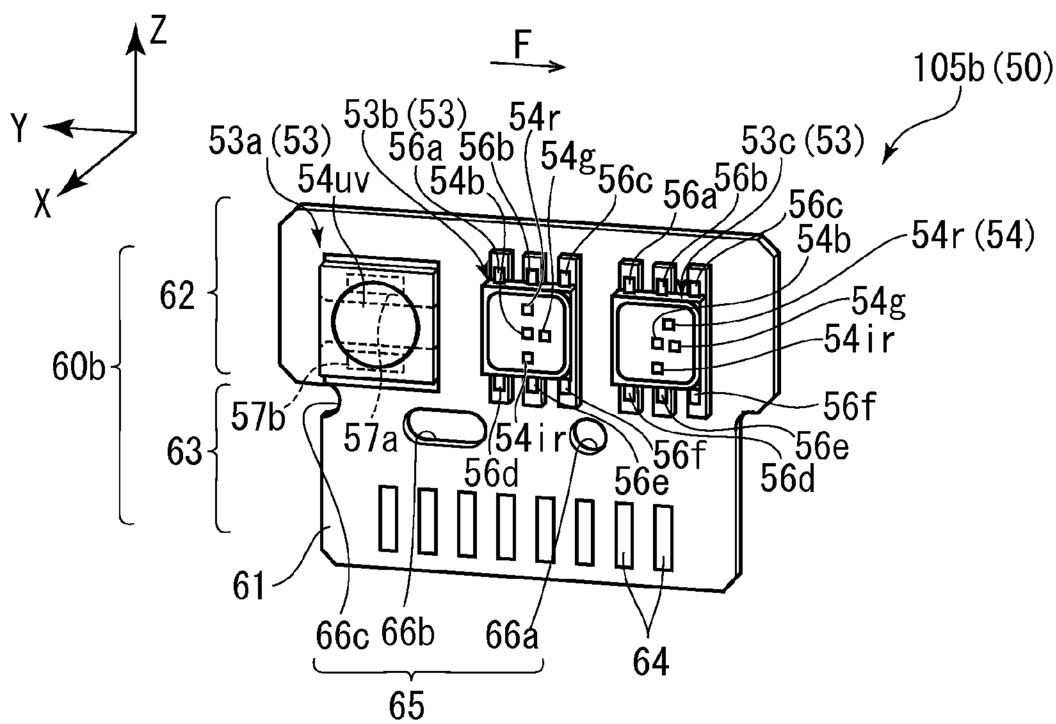
FIG.9B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54ir
60b
56f
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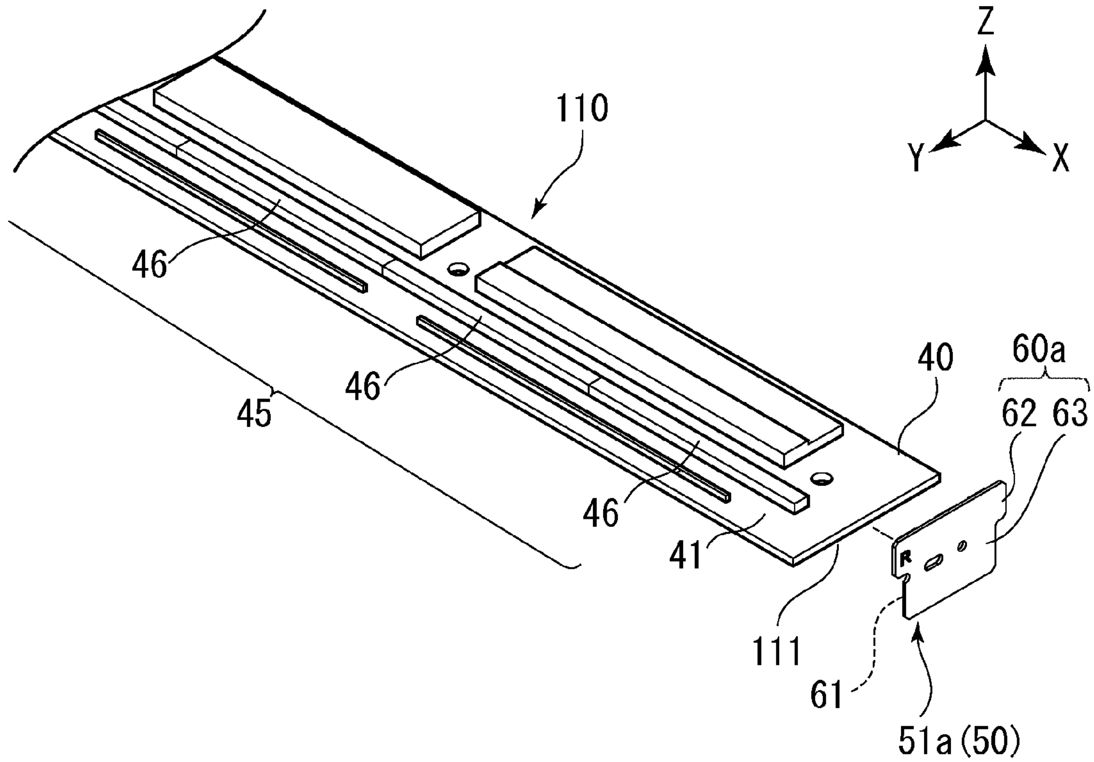
66c
66b
66a
64
65

FIG.10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111
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Y
X

FIG.11

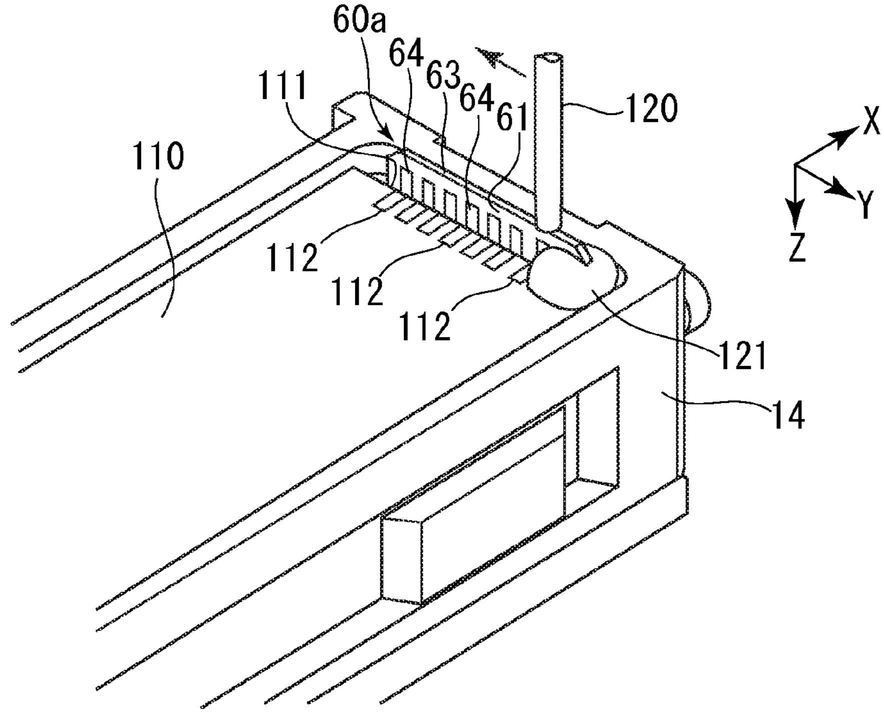
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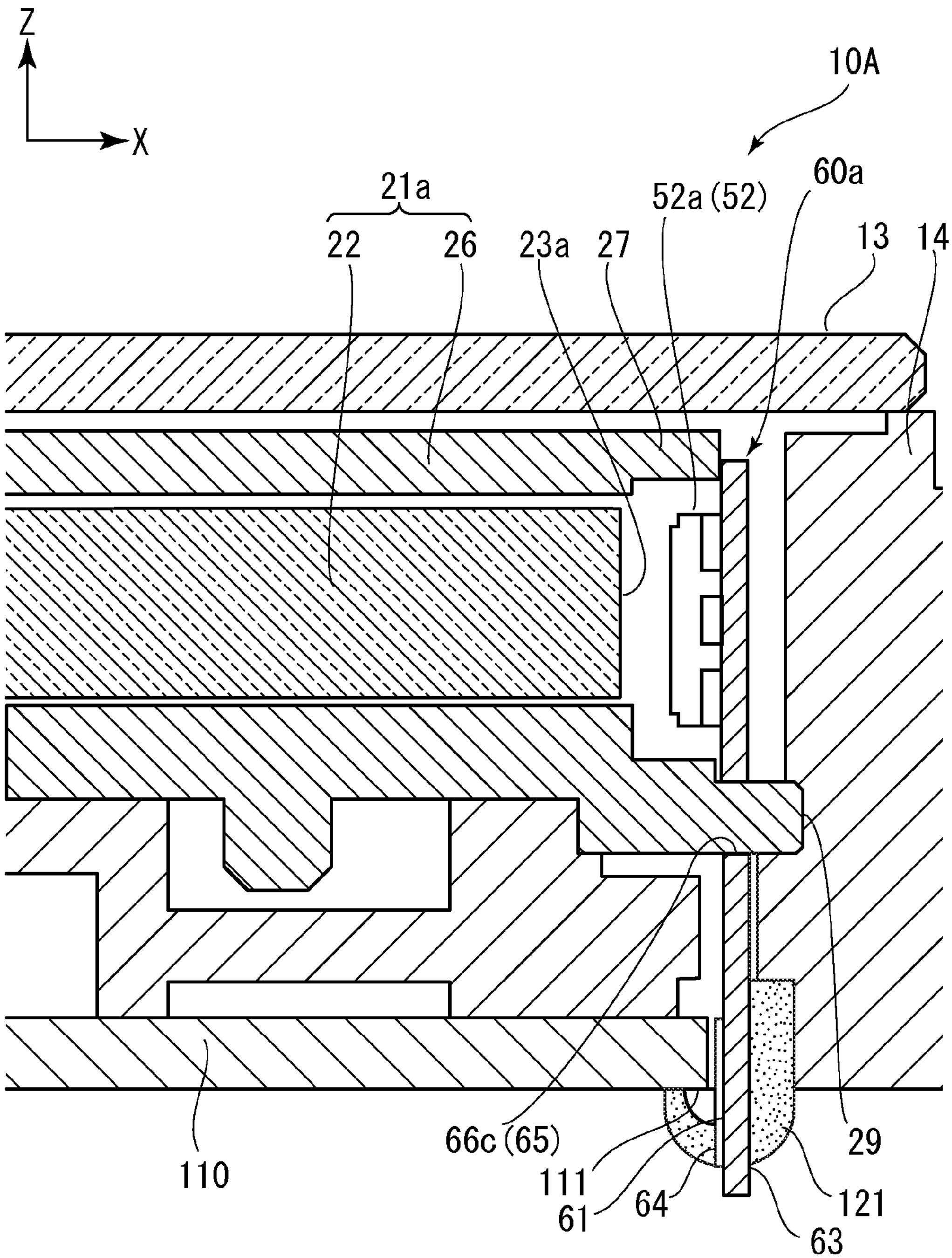
FIG.12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60a
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66c (65)
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64
63
121
29

IMAGE SENSOR UNIT, IMAGE READING APPARATUS, AND PAPER SHEET DISTINGUISHING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2013-219626, filed on Oct. 22, 2013, and the prior Japanese Patent Application No. 2014-208144, filed on Oct. 9, 2014, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image sensor unit, an image reading apparatus, and a paper sheet distinguishing apparatus.

2. Description of the Related Art

In general, an image reading apparatus including an image sensor unit is used to read an image. An image sensor unit disclosed in Patent Document 1 includes light emitting units each arranged to face incident surfaces in a longitudinal direction of a plurality of light guides. Each light emitting unit includes an LED chip arranged to face the incident surface and a plurality of lead wires connected to a plate by soldering or the like.

Patent Document 1

Japanese Laid-open Patent Publication No. 2005-198106

To assemble the image sensor unit of the above-mentioned Patent Document 1, the lead wires need to be soldered after inserting the lead wires into vies formed on the plate, for each light emitting unit, Therefore, the number of light emitting units arranged to face the incident surfaces of the light guides increases with an increase in the number of light guides. Therefore, there is a problem that the number of processes for the insertion into the vias increases, and the work is troublesome. Furthermore, to insert the lead wires of a plurality of light emitting units into a plurality of vias of the plate, the lead wires of the plurality of light emitting units need to be aligned with the vias of the plate, and the work is troublesome.

SUMMARY OF THE INVENTION

The present invention has been made in view of the above-mentioned problems, and an object of the present invention is to provide an image sensor unit and the like that can be easily assembled.

The present invention provides an image sensor unit including: a plurality of light sources each including a light emitting element a plurality of light guides that are arranged in parallel to face incident surfaces on one side in a longitudinal direction for each of the plurality of light sources and that guide light from the plurality of light sources to an illuminated body; an image sensor that converts light from the illuminated body to an electric signal; a sensor substrate for mounting the image sensor; and a circuit board that is provided with the plurality of light sources on a same mounting surface and that is arranged on the sensor substrate on one side in the longitudinal direction of the plurality of light guides, wherein the sensor substrate includes a connection portion on one side in the longitudinal direction of the sensor substrate, and the circuit board is connected to the sensor substrate by connecting a connecting portion including a plurality of external connection pads to the connection portion.

The present invention provides an image reading apparatus including: the above-mentioned image sensor unit; and a transfer portion that relatively transfers the image sensor unit and the illuminated body.

The present invention provides a paper sheet distinguishing apparatus including: the above-mentioned image sensor unit; a transfer portion that transfers a paper sheet as the illuminated body; a storage portion that stores reference data as a reference for distinguishing the paper sheet; and a comparison portion that compares image information read by the image sensor unit and the reference data stored in the storage portion to distinguish the paper sheet.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view showing a configuration of essential parts of an image reading apparatus of a first embodiment;

FIG. **2** is an exploded perspective view of a lower image sensor unit;

FIG. **3** is an enlarged exploded perspective view of the lower image sensor unit;

FIG. **4** is a perspective view showing a periphery of an end on one side in to longitudinal direction of a reflection reading light guide portion;

FIG. **5**A is a perspective view showing a configuration of a first light source portion of the first embodiment;

FIG. **5**B is a perspective view showing a configuration of a second light source portion of the first embodiment;

FIG. **6** is a sectional view of a part of the lower image sensor unit of the first embodiment;

FIG. **7**A is a sectional view of as lower image sensor unit of a second embodiment;

FIG. **7**B is a perspective view showing a configuration of a first light source portion of the second embodiment;

FIG. **8**A is a sectional view of an image sensor unit of a third embodiment;

FIG. **8**B is a perspective view showing a configuration of a first light source portion of the third embodiment;

FIG. **9**A is a perspective view showing a configuration of a first light source portion of a fourth embodiment;

FIG. **9**B is a perspective view showing a configuration of a second light source portion of the fourth embodiment;

FIG. **10** is a perspective view showing a configuration of a sensor substrate and a first light source portion of a fifth embodiment;

FIG. **11** is a diagram for explaining an assembly method of an image sensor unit of the fifth embodiment; and

FIG. **12** is a sectional view of a part of a lower image sensor unit of the fifth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of an image sensor unit and an image reading apparatus according to the present invention will, be described with reference to the drawings. In the following description, three-dimensional directions will be indicated by X, Y, and Z arrows. The X direction denotes a main-scan direction, the Y direction denotes a sub scan direction perpendicular to the main-scan direction, and the Z direction denotes a perpendicular direction (vertical direction).

(First Embodiment)

An image reading apparatus **100** according to the present embodiment functions as a paper sheet distinguishing apparatus that authenticates a paper sheet, such as a bill and a security.

FIG. **1** shows a configuration of essential parts of the image reading apparatus **100** including an image sensor unit portion **10** according to the present embodiment. First, the entire configuration will be schematically described. In the present embodiment, a typical example of an, illuminated body is a bill S. However, the present invention can also be applied to objects other than the bill S.

At predetermined positions in the image reading apparatus **100**, a pair of conveyor rollers **101**A and **101**B and a pair of conveyor rollers **102**A and **102**B as transfer portions for conveying the bill S held therebetween are disposed at predetermined intervals in a conveyance direction F of the bill S. The conveyor rollers **101**A, **101**B, **102**A, and **102**B are designed to be rotated by a driving mechanism to transfer the bill S relative to the image sensor unit portion **10** at a predetermined conveyance speed in the conveyance direction F.

The image sensor unit portion **10** is disposed between the pair of conveyor rollers **101**A and **101**B and the pair of conveyor rollers **102**A and **102**B to provide a gap that forms a conveyance path through which the bill S can pass and reads an image on the bill S conveyed. The image sensor unit portion **10** includes a lower image sensor unit **10**A that serves as a first image sensor unit located below the conveyance path for the bill S and an upper image sensor unit **10**B that serves as a second image sensor unit, located above the conveyance path for the bill In the present embodiment, the lower image sensor unit **10**A and the upper image sensor unit **10**B have the same configuration and are disposed symmetrically about a center line Oc shown in FIG. **1**. Each of the lower image sensor unit **10**A and the upper image sensor unit **10**B includes an image reading portion **11** for reading an image that includes a reflection reading illumination portion **11**A that emits light for reflection reading (reflection reading light) to the bill S and a transmission reading illumination portion **12** that emits light for transmission reading (transmission reading light) to the bill S. The image reading portion **11** (reflection reading illumination portion **11**A) and the transmission reading illumination portion **12** allow reading of image information based on the reflected light, from the bill S and reading of image information based on the transmitted light. The transmission reading illumination portion **12** of the upper image sensor unit **10**B is disposed in a position corresponding to the image reading portion **11** of the lower image sensor unit **10**A. The image reading portion **11** of the upper image sensor unit **10**B is disposed in a position corresponding to the transmission reading illumination portion **12** of the lower image sensor unit **10**A. Thus, in the present embodiment, the lower image sensor unit **10**A and the upper image sensor unit **10**B can read both sides of the bill S in one conveyance.

A comparison portion **103** acquires image information read by the lower image sensor unit **10**A and the upper image sensor unit **10**B. The comparison portion **103** also reads reference data stored in a storage portion **104** and compares the reference data with the acquired image information to distinguish authenticity of the bill S.

Next, configurations of the lower image sensor unit **10**A and the upper image sensor unit **10**B will be described. Since the lower: image sensor unit **10**A and the upper image sensor unit **10**B have the same configuration, the lower image sensor unit **10**A will be particularly described here. FIG. **2** is an exploded perspective view of the lower image sensor unit **10**A. FIG. **3** is an enlarged perspective view of one side in the longitudinal direction of the lower image sensor unit **10**A shown in FIG. **2**. The lower image sensor unit **10**A has a generally rectangular shape, the longitudinal direction being aligned with the main-scan direction. The sub-scan direction perpendicular to the main-scan direction being aligned with the conveyance direction F of the bill S.

The lower image sensor unit **10**A includes a cover glass **13**, a frame **14**, a light guide portion **20**, a light condenser **38**, a sensor substrate **40**, an image sensor **45**, a light source portion **50**, and the like. Among the constituent members, the light guide portion **20** and the light source portion **50** function as an illumination apparatus. Among the above-mentioned constituent members, the cover glass **13**, the frame **14**, the light guide portion **20**, the sensor substrate **40**, and the image sensor **45** are formed in lengths according to a width dimension in the main-scan direction of the bill S to be read.

The cover glass **13** prevents dust from entering the frame **14**. The cover glass **13** has a substantially plate shape, and for example, a double-sided tape or the like is used to fix the cover glass **13** so as to cover the frame **14** from above. The cover glass **13** is not limited to glass, and for example, a transparent resin material, such as an acrylic resin and polycarbonate, can be applied.

The frame **14** is a housing member that houses the constituent members of the lower image sensor unit **10**A. The frame **14** is substantially rectangular solid. that is long in the main-scan direction and is formed to be able to position and support the constituent members inside. As shown in FIG. **1**, a light condenser housing portion **15** that houses a light condenser **38** is formed in the main-scan direction, at substantially the center of the frame **14**. Light guide housing portions **16** that house the light guide portion **20** are formed on the frame **14**, on both sides across the light condenser housing portion **15**. On a lower surface of the frame **14**, a substrate housing portion **17** for arranging the sensor substrate **40** is formed in a concave shape from the outside of the frame **14** throughout the main-scan direction. The frame **14** can be made of a resin material such as polycarbonate.

The light guide portion **20** includes three light guide portions, a first reflection reading light guide portion **21***a*, a second reflection reading light guide portion **21***b*, and a transmission reading light guide portion **31**.

The first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b* have substantially the same configuration and are disposed line-symmetrically about an optical axis Z_1 of the light condenser **38** shown in FIG. **1**, and the first reflection reading light guide portion **21***a* will be described here.

As shown in FIG. **3**, the first reflection reading light guide portion **21***a* includes a light guide **22** and a light guide holding member **26**. The light guide **22** emits light from the light source portion **50** to the bill S as reflection reading light. The light guide **22** is formed by, for example, an acrylic transparent resin material and is formed in a rod shape that is long in the main -scan direction. The light guide **22** includes an incident surface **23***a* formed at an end on one side in he longitudinal direction and includes an incident surface **23***b* at an end on the other side. The incident surfaces **23***a* and **23***b* are orthogonal to the main-scan direction, and the light from the light source portion **50** enters.

The light guide **22** also includes, on a surface facing the bill S, an emission surface **24** for emitting the light incident on the light guide **22** toward the bill S. In the light guide **22**, surfaces in the main-scan direction other than the emission surface **24** function as reflection surfaces for reflecting the light entered from the incident surfaces **23***a* and **23***b* and propagating the light in the longitudinal direction of the light guide **22**.

The light guide holding member **26** holds the light guide **22**. The light guide holding member **26** is formed in substantially the same length as the light guide **22** in the main-scan direction. As shown in FIG. **1**, the light guide holding member **26** has a substantially C-shaped cross section, and the side on which the light condenser **38** is arranged is open.

The light guide holding member **26** covers a part of the emission surface **24** of the light guide **22** from above to control the direction of the light emitted to the bill S. An inner surface of the light guide holding member **26** functions as a reflection surface for reflecting the light incident on the light guide **22** toward the side of the emission surface **24** of the light guide **22**.

FIG. **4** is a perspective view showing a periphery of an end on one he in the longitudinal direction of the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b*, As shown in FIG. **4**, a plate-like eaves portion is integrally formed on the upper side at the end on one side in the longitudinal direction of the light guide holding member **26**, and an alignment portion **28** is integrally formed on the lower side. The eaves portion **27** blocks and prevents the light from the light source portion **50** from leaking from between the incident surface **23***a* of the light guide **22** and the light source portion **50**. The alignment portion **28** is a projection protruding toward the light source portion **50**, and for example, a plurality of (two) cylindrical projections **29** are formed. The alignment portion **28** is engaged with an aligning portion **65** of a first circuit board **60***a* described later to position the light guide **22** and the light source portion **50** through the light guide holding member **26**.

The eaves portion **27** and the alignment portion **28** are similarly formed at an end on the other side in the longitudinal direction of the light guide holding member **26**.

As shown in FIG. **3**, the transmission reading light guide portion **31** includes a light, guide **32** and a light guide holding member **36**. The light guide **32** emits the light from the light source portion **50** to the bill S as transmission reading light. The light guide **32** is formed by, for example, an acrylic transparent resin material and is formed in a rod shape that is long in the main-scan direction. In the light guide **32**, an incident surface **33***a* is formed at an end on one side in the longitudinal direction, and an incident surface **33***b* is formed at an end on the other side. The incident surfaces **33***a* and **33***b* are orthogonal to the main-scan direction, and the light from the light source portion **50** enters

In the light guide **32**, an emission surface **34** for emitting the light incident on the light guide **32** toward the bill S is formed on a surface facing the bill S. In the light guide **32**, surfaces in the main-scan direction other than the emission surface **34** function as reflection surfaces for reflecting the light entered from the incident surfaces **33***a* and **33***b* and propagating the light in the longitudinal direction in the light guide **32**.

The light guide holding member **36** holds the light guide **32**. The light guide holding member **36** is formed in substantially the same length as the light guide **32** in the main-scan direction. As shown in FIG. **1**, the light guide holding member **36** has a substantially C-shaped cross section, and the upper side is open.

The light guide **22** of the first reflection reading light guide portion **21***a*, the light guide **22** of the second reflection reading light guide portion **21***b*, and the light guide **32** of the transmission reading light guide portion **31** are arranged in parallel in the sub scan direction in the frame **14**.

The light condenser **38** is an optical member that focuses the reflected light from the bill S and the transmitted light from the bill S on the image sensor **45**. The light condenser **38** can be for example, a rod-lens array with a plurality of image forming elements (rod lenses) of an erect equal magnification image forming type linearly arranged in the main-scan direction. The configuration of the light condenser **38** is not limited to the above-mentioned configuration as long as an image can be formed on the image sensor **45**. The light condenser **38** can be an optical member with various conventionally well-known light condensing functions, such as various micro-lens arrays.

The sensor substrate **40** is formed in a planar shape that is long in the main-scan direction. A mounting surface **41** of the sensor substrate **40** is orthogonal to the vertical direction. A drive circuit and the like for emitting light from the light source portion **50** or driving the image sensor **45** are mounted on the mounting surface **41** of the sensor substrate **40**. A connection hole **42***a* as a connection portion for inserting the first circuit board **60***a* is formed at an end on one side in the longitudinal direction of the sensor substrate **40**, and a connection hole **42***b* as a connection portion for inserting a second circuit board **60***b* is formed at an end on the other side. The connection holes **42***a* and **42***b* have an elongated shape that is long in the sub-scan direction.

The image sensor **45** is mounted on the sensor substrate **40** and arranged below the condenser **38**. The image sensor **45** includes a predetermined number of image sensor ICs **46** that are configured by a plurality of photoelectric conversion elements corresponding to the resolution of reading by the lower side image sensor unit **10**A and that are linearly arranged on the mounting surface **41** in the main-scan direction. The image sensor **45** receives the reflected light and the transmitted light from the bill S focused by the light condenser **38** and converts the light to an electric signal. The image sensor **45** is not limited to the above-mentioned configuration as long as the reflected light and the transmitted light from the bill S can be converted to an electric signal. The image sensor ICs **46** can be various conventionally well-known image sensor ICs.

The light source portion **50** generates light to emit the light to the bill S through the light guide portion **20**. The light source portion **50** includes a first light source portion **51***a* arranged at an end on one side in the longitudinal direction of the light guide portion **20** and a second light source portion **51***b* arranged at an end on the other side.

FIG. **5**A is a perspective view showing a configuration of the first light source portion **51***a*. The first light source portion **51***a* includes a plurality of light sources **52** (**52***a*, **52***b*, and **52***c*) mounted on a same mounting surface **61** of the first circuit board **60***a*. The light sources **52** can be so-called top-view surface-mount LED packages, in which LED chips **54** as light emitting elements are mounted on the surface. The surface-mount LED packages are widely used, and the costs can be reduced by using the LED packages in the lower side image sensor unit **10**A.

The plurality of light sources **52** (**52***a*, **52***b*, and **52***c*) are mounted in parallel in the sub-scan direction (conveyance direction F), with the light emitting surfaces facing the main-scan direction.

In the first light source portion **51***a*, the light source mounted on the upstream in the conveyance direction F is a first reflection reading light source **52***a* arranged to face the incident surface **23***a* of the light guide **22** of the first reflection reading light guide portion **21***a*. The first reflection reading light source **52***a* is arranged in a state that a plurality of (for example, four) LED chips **54***r*, **54***g*, **54***b*, and **54***ir* are sealed by a transparent resin. The LED chips **54***r*, **54***g*, and **54***b* emit visible light with emission wavelengths of red, green, and blue (hereinafter, also called RGB), respectively. The LED chip **54***ir* emits light with an emission wavelength of infrared light (hereinafter, also called IR). The reason that the light with an emission wavelength of invisible light, such as infrared light, is emitted is to read an image on the bill S printed by an invisible ink.

The first reflection reading light source **52***a* includes a plurality of terminals **56***a* to **56***f* as electrodes extending from a rectangular package body **55**. The terminals **56***a* to **56***c* extend from a side surface on one side in the sub-scan direction of the package body **55**, and the terminals **56***d* to **56***f* extend from a side surface on the other side in the sub-scan direction of the package body **55**.

In the first light source portion **51***a*, the light source mounted at the center is a second reflection reading light source **52***b* arranged to face the incident surface **23***a* of the light guide **22** of the second reflection reading light guide portion **21***b*. The second reflection reading light source **52***b* is arranged in a state that an LTD chip **54***uv* is sealed by a transparent resin. The LED chip **54***uv* emits light with an emission wavelength of ultraviolet light (hereinafter, also called UV).

The second reflection reading light source **52***b* includes electrodes **57***a* and **57***b* formed on the back surface of the rectangular package body **55**. The electrodes **57***a* and **57***b* are separately positioned in the sub-scan direction.

In the first light source portion **51***a*, the light source mounted on the downstream in the conveyance direction F is a transmission reading light source **52***c* arranged to face the incident surface **33***a* of the light guide **32** of the transmission reading light guide portion **31**. The transmission reading light source **52***c* is arranged in a stare that an LED chip **54***uv* is sealed by a transparent resin.

The transmission reading light source **52***c* includes electrodes **57***a* and **57***b* formed on the back surface of the rectangular package body **55**. The electrodes **57***a* and. **57***b* are separately positioned in the sub-scan direction.

The first circuit board **60***a* is formed in a planar shape. The upper side is a mounting portion **62** provided with the plurality of light sources **52**, and the lower side is a connecting portion **63** connected to the connection hole **42***a* of the above-mentioned sensor substrate **40**.

A plurality of light source connection pads **67***a* to **67***j* are exposed and formed on the mounting surface **61** of the mounting portion **62**. The terminals **56***a* to **56***f* of the first reflection reading light source **52***a* are soldered and connected to the light source connection pads **67***a* to **67***f*, respectively, and the first reflection reading light source **52***a* is mounted on a predetermined position of the mounting portion **62**. The light source connection pads **67***a* to **67***f* are formed in a size exceeding the terminals **56***a* to **56***f* in the sub-scan direction so that the terminals **56***a* to **56***f* extending in the sub-scan direction can be easily soldered to the light source connection pads **67***a* to **67***f*, More specifically, the light source connection pads **67***a* to **67***f* are formed so that a length Dh in the vertical direction (direction orthogonal to width direction) is shorter than a length Dw in the width direction (sub-scan direction) in the outer shape of the light source connection pads **67***a* to **67***f* combined.

The terminals **57***a* and **57***b* of the second reflection reading light source **52***b* are soldered and connected to the light source connection pads **67***g* and **67***h*, respectively, and the second reflection reading light, source **52***b* is mounted on a predetermined position of the mounting portion **62**. The light source connection pads **67***g* and **67***h* are formed in a size exceeding the package body **55** in the sub-scan direction so that the terminals **57***a* and **57***b* separated in the sub-scan direction can be easily soldered to the light, source connection pads **67***g* and **67***h*. More specifically, the light source connection pads **67***g* and **67***h* are formed so that the length in the vertical direction is shorter than the length in the width direction in the outer shape of the light source connection pads **67***g* and **67***h* combined.

The terminals **57***a* and **57***b* of the transmission reading light sources **52***c* are soldered and connected to the light source connection pads **67***i* and **67***j*, respectively, and the transmission reading light source **52***c* is mounted on a predetermined position of the mounting portion **62**. As in the light source connection pads **67***g* and **67***h*, the light source connection pads **67***i* and **67***j* are formed so that the length in the vertical direction is shorter than the length in the width direction in the outer shape of the light source connection pads **67***i* and **67***j* combined,

In this way, the light source connection pads **67***a* to **67***f*, **67***g* and **67***h*, and **67***i* and **67***j* are formed so that the length in the vertical direction is shorter than the length in the width direction in the outer shapes of the light source connection pads **67***a* to **67***f*, **67***g* and **67***h*, and **67***i* and **67***j* combined, respectively. Therefore, the length in the vertical direction of the mounting portion **62** can be reduced.

Meanwhile, a plurality of (for example, eight) external connection pads **64** for electrical connection with the sensor substrate **40** are formed on the connecting portion **63** at predetermined intervals in he conveyance direction F. A circuit pattern not shown is formed on the connecting portion **63**, and the light source connection pads **67***a* to **67***j* and the external connection pad **64** are electrically connected. An aligning portion **65** is also formed on the connecting portion **630** The aligning portion **65** includes: insertion holes **66***a* and **66***b* for inserting the projections **29** of the light guide holding member **26**; and a cut-out portion **66***c*.

Meanwhile, FIG. 5B is a perspective view showing a configuration of the second light source portion **51***b*. The second light source portion **51***b* includes a plurality of light sources **53** (**53***a*, **53***b*, and **53***c*) mounted on the same mounting surface **61** of the second circuit board **60***b*. in the second light source portion **51***b*, as in the first light source portion **51***a*, a plurality of light sources (**53***a*, **53***b*, and **53***c*) are mounted in parallel in the sub-scan direction (conveyance direction F), with the light emitting surfaces facing the main-scan direction.

In the second light source portion **51***b*, the light source mounted on the upstream in the conveyance direction F is a first reflection reading light source **53***a* arranged to face the incident surface **23***b* of the light guide **22** of the first reflection reading light guide portion **21***a*. The first reflection reading light, source **53***a* is arranged in a state that an LED chip **54***uv* is sealed by a transparent resin.

In the second light source portion **51***b*, the light source mounted at the center is a second reflection reading light source **53***b* arranged to face the incident surface **23***b* of the light guide **22** of the second reflection reading light guide portion **21***b*. The second reflection reading light source **53***b* is arranged in a state that a plurality of (for example, four) LED chips **54***r*, **54***g*, **54***b*, and **54***ir* are sealed by a transparent resin.

In the second light source portion **51***b*, the light source mounted on the downstream in the conveyance direction F is a transmission reading light source **53***c* arranged to face the incident surface **33***b* of the light guide **32** of the transmission reading light guide portion **31**. The transmission reading light source **53***c* is arranged in as state that a plurality of (for example, four) LED chips **54***r*, **54***g*, **54***b*, and **54***ir* are sealed by a transparent resin.

The light sources of the second light source portion **51***b* includes electrodes as in the light sources of the first light source portion **51***a*. The same reference numerals as in the first light source portion **51***a* are designated here,

The second circuit board **60***b* is formed in a planar shape. The upper side is a mounting portion **62** provided with the plurality of light sources **52**, and the lower side is a connecting portion **63** connected to the connection hole **42***b* of the sensor substrate **40**. As in the first light source portion **51***a*, light source connection pads are also formed on the mounting surface **61** of the mounting portion **62**. More specifically, as in the first light source portion **51***a*, the second circuit board **60***b* is also formed, so that the length in the vertical direction is shorter than the length in the width direction in the outer shape of the light source connection pads combined. Therefore, the length in the vertical direction of the mounting portion **62** can be reduced.

The outer shape of the second circuit board **60***b* is mirror-symmetric with respect to the outer shape of the first circuit board. **60***a*. More specifically, the outer shape of the second circuit board **60***b* is line-symmetric about a center line Cv of the first circuit board **60***a* shown in FIG. **5**A. The same components are designated with the same reference numerals, and the description will not be repeated.

Therefore, the first reflection reading light source **52***a* and the first reflection reading light source **53***a* arranged on both ends in the longitudinal direction of the first reflection reading light guide portion **21***a* cause red, green, blue, infrared, and ultraviolet lights to enter the first reflection reading light guide portion **21***a* through the incident surfaces **23***a* and **23***b*.

Similarly, the second reflection reading light source **52***b* and the second reflection reading light source **53***b* arranged on both ends in the longitudinal direction of the second reflection reading light guide portion **21***b* cause red, green, blue, infrared, and ultraviolet lights to enter the second reflection reading light guide portion **21***b* through the incident surfaces **23***a* and **23***b*.

Similarly, the transmission reading light source **52***c* and the transmission reading light source **53***c* arranged on both ends in the longitudinal direction of the transmission reading light guide portion **31** cause red, green, blue, infrared, and ultraviolet lights to enter the transmission reading light guide portion **31** through the incident surfaces **33***a* and **33***b*.

Next, basic operation of the image reading portion **11** configured as described above will be described. The image reading portion **11** successively activates the LED chips **54***r*, **54***g*, **54***b*, **54***ir*, and **54***uv* of the first reflection reading light sources **52***a* and **53***a* and the second reflection reading light sources **52***b* and **53***b*, with respect to the bill S conveyed by the conveyor rollers **101**A, **1015**, **102**A, and **102**B in the conveyance direction F at a predetermined conveyance speed. The light emitted from the first reflection reading light sources **52***a* and **53***a* and the second reflection reading light sources **52***b* and **53***b* enters the light guides **22** of the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b* from the incident surfaces **23***a* and **23***b*. The incident light is emitted as reflection reading light from the emission surfaces **24** of the light guides **22** of the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b*, toward a reading position O_1 of the bill S as representatively indicated by arrows L_1 in FIG. **1**. The reflection reading light is linearly and uniformly illuminated on one of the surfaces (lower surface) of the bill S in the main-scan direction, from two directions across the light condenser **38**.

The reflection reading light is reflected by the bill S, and the reflected light is focused on the image sensor **45** through the light condenser **38**. The image sensor **45** converts the focused reflected light to an electric signal, and a signal processing unit not shown processes the electric signal.

In this way, one scan line of all, of the RGB, IR, and UV reflected lights is read, and the reading operation of one scan line in the main-scan direction of the bill S is completed. After the completion of the reading operation of one scan line, reading operation of the next scan line is performed in the same way, along with the movement of the bill S in the sub-scan direction. In this way, the reading operation of one scan line is repeated while conveying the bill S in the conveyance direction F, The entire surface of the bill S is successively scanned, and image information is read based on the reflected light.

The image reading portion **11** of the upper image sensor unit **10**B performs the same operation for the other surface (upper surface).

Next, operation of the transmission reading illumination portion **12** configured as described above will be described. The transmission reading illumination portion **12** successively activates the LED chips **54***r*, **54***g*, **54***b*, **54***ir*, and **54***uv* of the transmission reading light sources **52***c* and **53***c*, with respect to the bill S conveyed by the conveyor rollers **101**A, **101**B, **102**A, and **102**B in the conveyance direction F at a predetermined conveyance speed. The light emitted from the transmission reading light sources **52***c* and **53***c* enters the transmission reading light guide portion **31** from the incident surfaces **33***a* and **33***b*. The incident light is emitted as transmission reading light from the emission surface **34** of the transmission reading light guide portion **31**, toward a reading position O_2 of the bill S as representatively indicated by an arrow L_2 in FIG. **1**. The transmission reading light is linearly and uniformly illuminated on one of the surfaces (lower surface) of the bill S in the main-scan direction.

The transmission reading light transmits through the bill S, and the transmitted light is focused on the image sensor **45** through the light condenser **38** of the upper image sensor unit **10**B. The image sensor **45** of the upper image sensor unit **10**B converts the focused transmitted light to an electric signal, and a signal processing unit not shown processes the electric signal.

In this way, one scan line of all of the RGB, IR, and UV transmitted lights is read, and the reading operation of one scan line in the main-scan direction of the bill S is completed. After the completion of the reading operation of one scan line, reading operation of the next scan line is performed in the same way, along with the movement of the bill S in the sub-scan direction. In this way, the reading operation of one scan line is repeated while conveying the bill S in the conveyance direction F. The entire surface of the bill S is successively scanned, and image information is read based on the transmitted light.

The transmission reading illumination portion **12** of the upper image sensor unit **10**B performs the same operation for the other surface (upper surface).

Next, an assembly method of the image sensor unit portion **10** configured as described above will be described.

The lower image sensor unit **10**A and the upper image sensor unit **10**B have substantially the same configuration, and the lower image sensor unit **10**A will be described here.

First, the constituent members of the lower image sensor unit **10**A are prepared. In this case, the plurality of light sources **52** are mounted in advance on predetermined positions as shown in FIG. **5**A and **5**B in the first circuit board **60***a* and the second circuit board **60***b*. The image sensor **45**, the drive circuit, and the like, are mounted in advance on predetermined positions in the sensor substrate **40**.

Next, the light guide holding members **26** hold the light guides **22** to form the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b*. Similarly, the light guide holding member **36** holds the light guide **32** to form the transmission reading light guide portion **31**.

Next, as shown in FIG. **4**, the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b* is maintained to face each other. In this state, the alignment portions **28** formed on one side in the longitudinal direction of the light guide holding members **26** and the aligning portion **65** of the first circuit board **60***a* are engaged and positioned. Specifically, the projections **29** of the alignment portions **28** are inserted into the insertion holes **66***a*, **66***b*, and the cut-out portion **66***c*. Two projections **29** are inserted into the insertion hole **66***b*.

Therefore, the first reflection reading light source **52***a* accurately faces the incident surface **23***a* of the light guide **22** of the first reflection reading light guide portion **21***a*, and the second reflection reading light source **52***b* accurately faces the incident surface **23***a* of the light guide **22** of the second reflection reading light guide portion **21***b*.

Similarly, the alignment portions **28** formed on the other side in the longitudinal direction of the light guide holding members **26** and the aligning portion **65** of the second circuit board **60***b* are engaged and positioned.

Therefore, the first reflection reading light source **53***a* accurately faces the incident surface **23***b* of the first reflection reading light guide portion **21***a*, and the second reflection reading light source **53***b* accurately faces the incident surface **23***b* of the second reflection reading light guide portion **21***b*.

Next, the light condenser **38** is housed in the light condenser housing portion **15** from the upper side of the frame **14**. Furthermore, the first reflection reading light, guide portion **21***a* and the second reflection reading light guide portion **21***b* including the positioned first circuit board **60***a* and second circuit board **60***b* are housed in the light guide housing portions **16** from the upper side of the frame **14**. Similarly, the transmission reading light guide portion **31** is housed in the light guide housing portion **16** from the upper side of the frame **14**. The cover glass **13** is fixed on the upper surface of the frame **14** to cover the upper side of the frame **14**.

Next, the frame **14** is vertically inverted so that the cover glass **13** serves as a lower surface, and the vertically inverted sensor substrate **40** is housed in the substrate housing portion **17**. In this case, the connecting portion **63** of the first circuit board **60***a* protruding from the frame **14** is inserted into the connection hole **42***a* formed on one side in the longitudinal direction of the sensor substrate **40**. The connecting portion **63** of the second circuit board **60***b* protruding from the frame **14** is inserted into the connection hole **42***b* formed on the other side in the longitudinal direction of the sensor substrate **40**. Therefore, the first circuit board **60***a* and the second circuit board **60***b* are connected to the ends in the longitudinal direction of the sensor substrate **40**.

In this case, only one location needs to be aligned at each of the end on one side and the end on the other side in the longitudinal direction of the sensor substrate **40** to insert the first circuit board **60***a* and the second circuit board **60***b*, and the workability for housing the sensor substrate **40** in the frame **14** is improved. More specifically, unlike in the conventional technique, a plurality of lead wires do not have to be aligned and inserted into a plurality of visa at the same time, and the first circuit board **60***a* and the second circuit board **60***b* can be easily connected to the sensor substrate **40**.

The external connection pads **64** of the first circuit board **60***a* and the second circuit board **60***b* exposed from the lower surface of the sensor substrate **40** are soldered to the sensor substrate **40** from the connection holes **42***a* and **42***b*. The sensor substrate **40** housed in the substrate housing portion **17** is fixed in the substrate housing portion **17** by, for example, heat caulking, and the lower image sensor unit **10**A is manufactured.

FIG. **6** is a sectional view of one side in the longitudinal direction of the manufactured lower image sensor unit **10**A and is equivalent to a sectional view of a I-I line shown in FIG. **1**. As shown in FIG. **6**, the projection **29** of the light guide holding member **26** is inserted into the cut-out portion **66***c* of the first circuit board **60***a*, and the light source **52** is housed in the frame **14** to face the incident surface **23***a* of the it guide **22**.

In this way, the image sensor unit of the present embodiment includes the first circuit board **60***a* including the plurality of light sources **52***a*, **52***b*, and **52***c* mounted on the same mounting surface **61**, and the first circuit board **60***a* is connected to the sensor substrate **40** on one side in the longitudinal direction of the plurality of light guides **22** and **32**. Therefore, the plurality of light sources **52***a*, **52***b*, and **52***c* can be connected to the sensor substrate **40** through he first circuit board **60***a* just by aligning and connecting the first, circuit board **60***a* and the sensor substrate **40** at one location, and the image sensor unit can be easily manufactured.

The image sensor unit of the present embodiment also includes the second circuit, board **60***b* including the plurality of light sources **53***a*, **53***b*, and **53***c* mounted on the same mounting surface **61**, and the second circuit board **60***b* is connected to the sensor substrate **40** on the other side in the longitudinal direction of the plurality of light guides **22** and **32** Therefore, as described above, the image sensor unit can be easily manufactured.

In the image sensor unit of the present embodiment, the plurality of light sources **52***a*, **52***b*, and **52***c* are arranged at the end on one side in the longitudinal direction of the light guides **22** and **32**, and the plurality of light sources **53***a*, **53***b*, and **53***c* are arranged at the end on the other side. Therefore, compared to when a plurality of light sources are arranged only on one side, the plurality of light sources **52** can be arranged to face the incident surfaces **23***a*, **23***b*, **33***a*, and **33***b* without increasing the areas of the incident surfaces **23***a* and **23***b* of the light guide **22** and the incident surfaces **33***a* and **33***b* of the light guide **32**.

(Second Embodiment)

In the first embodiment, the case of arranging the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b* on both sides across the light condenser **38** has been described. In a second embodiment, a case of arranging just one reflection reading light guide portion **81** on one side of the light condenser **38** will be described.

FIG. **7**A is a sectional view showing a lower image sensor unit **80**A of the second embodiment. The same components as in the first embodiment are designated with the same reference numerals, and the description will not be repeated. As shown in FIG. **7**A, the lower image sensor unit **80**A does not include the first reflection reading light guide portion **21***a* of the first embodiment and includes just one reflection reading light Guide portion **81**. Therefore, the lower image sensor unit **80**A includes two light guide portions, the reflection reading light guide portion **81** and the transmission reading light guide portion **31**.

FIG. **7**B is a per view showing a light source portion **82***a* arranged at an end on one side in the longitudinal direction of the reflection reading light guide portion **81** and the transmission reading light guide portion **31** and mounted on a first circuit board **83***a*. The same components as in the first embodiment are designated with the same reference numerals, and the description will not be repeated,

As shown in FIG. **7**B, the first circuit board **83***a* includes a first light source **84***a* and a second light source **84***b* mounted in parallel on the same mounting surface **61**. The first light source **84***a* faces the Incident surface **23***a* of the reflection reading light guide portion **81**, and the second light source **84***b* faces the incident surface **33***a* of the transmission reading light guide portion **31**.

According to the present embodiment, the plurality of light sources **84***a* and **84***b* can he connected to the sensor substrate **40** through the first circuit board **83***a* just by aligning and inserting the connecting portion **63** of the first circuit hoard **83***a* into the connection hole **42***a* of the sensor substrate **40**, and the image sensor unit can be easily manufactured. Although not shown, a light source portion may also be arranged at an end on the other side in the longitudinal direction of the reflection reading light guide portion **81** and the transmission reading light guide portion **31**. In this case, the light source portion has a configuration excluding the first light source **53***a* shown in FIG. **5**B, and a second circuit board has a shape line-symmetric about the center line Cv of the first, circuit board **83**.

(Third Embodiment)

In the first embodiment, the case of arranging the transmission reading light guide portion **31** to emit the transmission reading light to the bill S has been described. In a third embodiment, a case excluding the transmission reading light guide portion **31** to emit just the reflection reading light will be described.

FIG. **8**A is a sectional view showing an image sensor unit **90** of the third embodiment. There is no need to read the transmitted light here, and the upper image sensor unit is not arranged above the bill S. The same components as in the first embodiment are designated with the seine reference numerals, and the description will not be repeated. As shown in FIG. **8**A, the image sensor unit **90** has a configuration excluding the transmission reading light guide portion **31** of the first embodiment. More specifically, the lower image sensor unit **90** includes two light guide portions, the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b*.

FIG. **8**B is a perspective view showing a light source portion **92***a* arranged at an end on one side in the longitudinal direction of the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b* and mounted on a first circuit board **93***a*. The same components as in the first embodiment are designated with the same reference numerals, and the description will not be repeated. As shown in FIG. **8**B, the first circuit board **93***a* includes the first light source **52***a* and the second light source **52***b* mounted in parallel on the same mounting surface **61**. The first light source **52***a* faces the incident surface **23***a* of the first reflection reading light guide portion **21***a*, and the second light source **52***b* faces the incident surface **23***a* of the second reflection reading light guide portion **21***b*.

According to the present embodiment, the plurality of light sources **52***a* and **52***b* can be connected to the sensor substrate **40** through the first circuit board **93***a* lust by aligning and inserting the connecting portion **63** of the first circuit board **93***a* into the connection hole **42***a* n the sensor substrate **40**, and the image sensor unit can be easily manufactured. Although not shown, a light source portion may also be arranged at an end on the other side in the longitudinal direction of the first reflection reading light guide portion **21***a* and the second reflection reading light guide portion **21***b*. In this case, the light source portion has a configuration excluding the third light source **53***c* shown in FIG. **5**B, and a second circuit board has the same shape as the first circuit board **93***a*.

(Fourth Embodiment)

In the first embodiment, the case has been described in which the light source connection pads of the first circuit board **60***a* and the second circuit board **60***b* are formed so that the outer shape of the plurality of light source connection pads combined is short in the vertical direction. In the present embodiment, a case in which the outer shape of a plurality of light source connection pads combined is short in the width direction will be described.

FIG. **9**A is a perspective view showing a configuration of a first light source portion **105***a* of the present embodiment. As shown in FIG. **9**A, the first reflection reading light source **52***a*, the second reflection reading light source **52***b*, and the transmission reading light source **52***c* of the first light source portion **105***a* are rotated 90 degrees from the first embodiment and mounted on the mounting surface **61**.

More specifically, the terminals **56***a* to **56***c* of the first reflection reading light source **52***a* extend from the upper surface in the vertical direction of the package body **55**, and the terminals **56***d* to **56***f* extend from the lower surface In the vertical direction of the package body **55**. The electrodes **57***a* and **57***b* of the second reflection reading light source **52***b* and the transmission reading light source **52***c* are separately positioned in the vertical direction.

Therefore, in the first circuit board **60***a* of the present embodiment, the length in the width direction is shorter than the length in the vertical direction in the outer shape of the light source connection pads combined. Therefore, the length in the width direction of the mounting portion **62** can be reduced.

FIG. **9**B is a perspective view showing a configuration of a second light source portion **105***b* of the present embodiment. As shown in FIG. **9**B, the first reflection reading light source **53***a*, the second reflection reading light source **53***b*, and the transmission reading light source **53***c* of the second light source portion **105***b* are rotated 90 degrees from the first embodiment and mounted on the mounting surface **61**. Therefore, in the second circuit board **60***b* of the present embodiment, the length in the width direction is shorter than the length in the vertical direction in the outer shape of the light source connection pads combined, as in the first light source portion **105***a*. Therefore, the length in the width direction of the mounting portion **62** can be reduced.

(Fifth Embodiment)

In the first embodiment, the case has been described in which the connecting portion **63** of the first circuit board **60***a* and the connecting portion **63** of the second circuit board **60***b* are inserted into the connection hole **42***a* and the connection hole **42***b* as the connection portions of the sensor substrate **40**, respectively, to connect the first circuit board **60***a* and the second circuit board **60***b* to the sensor substrate **40**. In the present embodiment, a case in which the connection portions are not hole-shaped will be described. The same components as in the first embodiment are designated with the same reference numerals, and the description will not be repeated.

FIG. **10** is a perspective view showing a configuration of a connection portion on one side in the longitudinal direction of a sensor substrate **110** of the present embodiment. A connection portion on the other side in the longitudinal direction of the sensor substrate **110** has the same configuration, and the illustration is omitted.

In the present embodiment, an edge portion **111** on one side of the sensor substrate **110** is a connection portion connected to the connecting portion **63** of the first circuit board **60***a*. In the state that the lower image sensor unit **10**A is assembled, an end face of the age portion **111** and the mounting surface **51** of the first circuit board **60***a* face each other. In this case, the end face of the edge portion **111** touches the mounting surface **61**. However, the end face of the edge portion **111** and the mounting surface **51** may be separated as long as the end face of the edge portion **111** and the mounting surface **61** can be electrically connected.

To assemble the image sensor unit portion **10**, the cover glass **13** is fixed to the upper surface of the frame **14**, the frame **14** is vertically inverted so that the cover glass **13** serves as a lower surface, and the vertically inverted sensor substrate **110** is housed in the substrate housing portion **17**, as in the first embodiment.

In this case, the mounting surf the connect portion **63** of the first circuit board **60***a* faces the end face of the edge portion **111** on one side in the longitudinal direction of the sensor substrate **110** as shown in FIG. **11**.

Subsequently, the external connection pads **64** of the first circuit board **60***a* exposed from the lower surface of the sensor substrate **110** are soldered to external connection pads **112** of the sensor substrate **110**.

An adhesive for maintaining the connection is used to bond the sensor substrate **110** and the first circuit board **60***a*. Specifically, a nozzle **120** is used to apply an adhesive **121** around the connecting portion **63** of the first circuit board **60***a* exposed from the lower surface of the sensor substrate **110** as shown in FIG. **11**.

FIG. **12** is a sectional view on one side in the longitudinal direction of the manufactured image sensor unit portion **10**. As shown in FIG. **12**, the adhesive **121** is entirely applied between the edge portion **111** of the sensor substrate **110** and the connecting portion **63** of the first circuit board **60***a*, and the sensor substrate **110** and the first circuit board **60***a* can be strongly connected. The adhesive **121** is also provided between the first circuit board **60***a* and the frame **14**. Therefore, the connection between the sensor substrate **110** and the first circuit board. **60***a* is also reinforced by the frame **14** through the adhesive **121**. The sensor substrate **110** and the first circuit board **60***a* may be connected only by the adhesive **121** provided between the first circuit board **60***a* and the frame **14**.

Although the case of connecting the first circuit board **60***a* and the sensor substrate **110** has been described here, the same applies to the case of connecting the second circuit hoard **60***b* and the sensor substrate **110**.

In this way, since the connection portion of the sensor substrate **110** of the present embodiment is formed by the edge portion **111** instead of forming the connection portion in a hole shape, the area from the connection hole **42***a* to the end face on one side of the sensor substrate **40** can be omitted from the sensor substrate **40** of the first embodiment. Therefore, the dimension in the main-scan direction of the sensor substrate **110** can be reduced, and the image sensor unit portion **10** can be downsized.

It is preferable to vertically, not obliquely, form the end face of the edge portion **111** in order to form the external connection pads **112** of the sensor substrate **110** near the first circuit board **60***a*.

Although the preferred embodiments of the present invention have been described, the present invention is not limited to the embodiments, and various modifications and changes can be made within the scope of the present invention.

Although the case of arranging the light sources on one side and the other side in the longitudinal direction of the light guide portion has been described in the embodiments, the light sources may be arranged only on one side in the longitudinal direction of the light guide portion.

In the first embodiment, the first light source **52***a* that emits RGB and IR is arranged on one side in the longitudinal direction of the first reflection reading light guide portion **21***a*, and the first light source **53***a* that emits UV is arranged on the other side. The case of arranging the second light source **52***b* that emits UV on one side in the longitudinal direction of the second reflection reading light guide portion **21***b* and arranging the second light source **53***b* that emits RGB and IR on the other side has been described. However, the arrangement is not limited to this as long as the lights (RGB, IR, and UV here) with emission wavelengths according to the specifications can be emitted to the bill S through the first reflection reading light guide portion **21***a* or the second reflection reading light guide portion **21***b*.

The case of arranging the third light source **52***c* that emits UV on one side in the longitudinal direction of the transmission reading light guide portion **31** and arranging the third light source **53***c* that emits RGB on the other side has been described in the first embodiment. However, the arrangement is not limited to this as long as the lights (RGB, IR, and UV here) with emission wavelengths according to the specifications can be emitted to the bill S through the transmission reading light guide portion **31**. When there is no need to emit IR and UV, light sources without light emitting elements that emit IR and UV can be used, or light emitting elements that emit IA and UV can be replaced with light emitting elements that emit RGB in the light sources.

Although the case in which the lower image sensor unit **10**A and the upper image sensor unit **10**B have the same configuration and are disposed symmetric about the center line Oc shown in FIG. **1** has been described in the first and second embodiments, the arrangement is not limited to this. More specifically, the lower image sensor unit **10**A and the upper image sensor unit **10**B may not have the same configuration. For example, the transmission reading illumination portion **12** may be included only on one side.

According to the present invention, a circuit board including a plurality of light sources mounted on the same mounting surface can be connected to a sensor substrate to easily assemble an image sensor unit.

It should be noted that the above embodiments merely illustrate concrete examples of implementing the present invention, and the technical scope of the present invention is not to be construed in a restrictive manner by these embodiments. That is, the present invention may be implemented in various forms without departing from the technical spirit or main features thereof.

What is claimed is:

1. An image sensor unit comprising:

a circuit board;

a plurality of light sources each comprising a light emitting element and disposed on a same side of the circuit board;

a plurality of elongated light guides disposed parallely to each other, and having light incident surfaces each disposed at one longitudinal end thereof, to guide light from the plurality of light sources to an illuminated body;

a sensor substrate having a first connecting portion disposed at one end thereof; and

an image sensor that converts light from the illuminated body to an electric signal and disposed on the sensor substrate;

wherein the circuit board is disposed at the one longitudinal end of the plurality of elongated light guides so that the plurality of light sources face the light incident surfaces disposed at the one longitudinal end of the plurality of elongated light guides, and

wherein the circuit board has a second connecting portion including a plurality of first external connection pads disposed at one end of the circuit board, the second connecting portion connected to the first connecting portion disposed at the one end of the sensor substrate.

2. The image sensor unit according to claim 1, wherein:

the first connecting portion includes an elongated connection hole, and

the circuit board is connected to the sensor substrate by inserting the second connecting portion into the elongated connection hole.

3. The image sensor unit according to claim 1, wherein:

the first connecting portion includes an edge portion on one side of the sensor substrate, and

the circuit board is connected to the sensor substrate by bonding the second connecting portion and the edge portion.

4. The image sensor unit according to claim 1, further comprising:

a plurality of light guide holding members that hold the plurality of elongated light guides respectively,

wherein the light guide holding members include projections protruding toward the circuit board respectively, and

wherein the light guide holding members position the circuit board by inserting the projections into insertion holes formed on the circuit board.

5. The image sensor unit according to claim 1, wherein:

the circuit board comprises a mounting portion provided with a plurality of light source connection pads corresponding to the plurality of light sources respectively, and

the plurality of light source connection pads are disposed so that a length in a vertical direction orthogonal to a width direction is shorter than a length in the width direction in an outer shape of the plurality of light source connection pads combined.

6. The image sensor unit according to claim 1, wherein:

the circuit board comprises a mounting portion provided with a plurality of light source connection pads corresponding to the plurality of light sources respectively, and

the plurality of light source connection pads are each disposed so that a length in a width direction is shorter than a length in a vertical direction orthogonal to the width direction in an outer shape of the plurality of light source connection pads combined.

7. The image sensor unit according to claim 1, wherein:

the circuit board comprises a first circuit board and a second circuit board,

the first circuit board has at least one first light source, among the plurality of light sources, disposed on the same side thereof,

the second circuit board has at least one second light source, among the plurality of light sources, disposed on the same side thereof,

the first circuit board is disposed facing one end side of the plurality of elongated light guides so that the at least one first light source each face the one end side of one of the plurality of elongated light guides, and

the second circuit board is disposed facing an opposite end side of the plurality of elongated light guides so that the at least one second light source each face the opposite end side of one of the plurality of elongated light guides.

8. The image sensor unit according to claim 7, wherein an outer shape of the first circuit board and an outer shape of the second circuit board are mirror-symmetric.

9. The image sensor unit according to claim 1, wherein the plurality of elongated light guides include at least three elongated light guides.

10. The image sensor unit according to claim 1, wherein the plurality of light sources comprise the light emitting elements that emit light with emission wavelengths of visible light, infrared light, and ultraviolet light.

11. An image reading apparatus comprising:

an image sensor unit comprising:

a circuit board;

a plurality of light sources each comprising a light emitting element and disposed on a same side of the circuit board;

a plurality of elongated light guides disposed parallely to each other, and having light incident surfaces each disposed at one longitudinal end thereof, to guide light from the plurality of light sources to an illuminated body;

a sensor substrate having a first connecting portion disposed at one end thereof; and

an image sensor that converts light from the illuminated body to an electric signal and disposed on the sensor substrate;

wherein the circuit board is disposed at the one longitudinal end of the plurality of elongated light guides so that the plurality of light sources face the light incident surfaces disposed at the one longitudinal end of the plurality of elongated light guides, and

wherein the circuit board has a second connecting portion including a plurality of first external connection pads disposed at one end of the circuit board, the second connecting portion connected to the first connecting portion disposed at the one end of the sensor substrate; and

a transfer portion that relatively transfers the image sensor unit and the illuminated body.

12. A paper sheet distinguishing apparatus comprising:

an image sensor unit comprising:

a circuit board;

a plurality of light sources each comprising a light emitting element and disposed on a same side of the circuit board;

a plurality of elongated light guides disposed parallely to each other, and having light incident surfaces each disposed at one longitudinal end thereof, to guide light from the plurality of light sources to an illuminated body;

a sensor substrate having a first connecting portion disposed at one end thereof; and

an image sensor that converts light from the illuminated body to an electric signal and disposed on the sensor substrate;

wherein the circuit board is disposed at the one longitudinal end of the plurality of elongated light guides so that the plurality of light sources face the light incident surfaces disposed at the one longitudinal end of the plurality of elongated light guides, and

wherein the circuit board has a second connecting portion including a plurality of first external connection pads disposed at one end of the circuit board, the second connecting portion connected to the first connecting portion disposed at the end of the sensor substrate;

a transfer portion that transfers a paper sheet as the illuminated body;

a storage portion that stores reference data as a reference for distinguishing the paper sheet; and

a comparison portion that compares image information read by the image sensor unit and the reference data stored in the storage portion to distinguish the paper sheet.

13. The image sensor unit according to claim **1**,

wherein the circuit board has a third connecting portion including a plurality of second external connection pads disposed at the other end of the circuit board,

wherein the third connecting portion is electrically connected to the second connecting portion, and

wherein the plurality of light sources are electrically connected to the third connecting portion.

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